Introduction to Soil Microbiology

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Description

The early phases of soil microbiology were often dominated by attempts to characterize soil populations using culture techniques through laboratory growth on selective (favors a particular group of microbes over others) or non-selective media. While these attempts produced valuable information, little more could be said other than that there was some number of colony-forming-units per gram (CFU g–1) of soil. We are becoming increasingly aware that our knowledge of the soil microbial community is far from complete. We have learned that many microbes in the soil exist in a "viable (alive) but nonculturable" state. It has long been observed that as many as 99% of microorganisms in a given soil sample, as quantified using microscopy or another direct technique, are not detected using traditional culture-based methods. This has led many to surmise that the vast majority (90%–99%) of soil microorganisms are not cultural. While it is true that lab culture remains elusive for many soil organisms, creative modifications in isolation methods, media, and incubation conditions have demonstrated that isolation and culture of many of these previously uncultured organisms may be possible if the appropriate conditions are provided. In fact, research using new culture-based methods has experienced somewhat of a renaissance in recent years due to the realization above and the need for cultured type-strains to characterize phenotypes that can be connected with the wealth of sequence data currently being produced through DNA-based approaches.

Understanding of Soil Microbiology

Despite tremendous advances in our understanding of soil microbiology, we still lack knowledge about the conditions under which most organisms exist within soil. This is partially because the scale at which we study soil properties is often mismatched with the scale of conditions impacting soil microorganisms. For example, we might determine soil pH by homogenizing 5 g of a soil sample in 10 mL of water and then measuring pH of the slurry, but these 5 g contain numerous pores (microsites) that can vary in pH. Water in a pore containing ammonia-oxidizers may have a lower pH because these organisms exude protons. In contrast, water in pores containing sulfate reducers could have a higher pH because their metabolism consumes protons.

This discrepancy between analytical and microbial relevant scales limits our ability to elucidate linkages between organisms and processes in soil. Adding to the spatial variability, soil microorganisms are unevenly distributed in soil, often occurring as micro colonies attached to soil solids within biofilms rather than as single cells floating in water films. A biofilm is a collection of organisms that excrete, or release upon cell death and lysis, extracellular polymeric substances (e.g., polysaccharides, DNA) that aid adherence to surfaces. As biofilms develop, cells are initially able to detach and move to other locations; however, as the biofilm matures, cells become permanently embedded. This is one of the ways that micro aggregates form. Biofilms are important to survival, as they buffer against desiccation and help to trap nutrients. Some are composed of a single species and others are multispecies.

Typically, a series of random samples is taken across representative areas that are described by uniform soil type, soil texture, and habitat characteristics. Samples of agricultural soils are often taken from specific soil depths (e.g., 0–20 or 0–30 cm); samples of forest soils are taken from specific soil horizons (e.g., litter horizon, A horizon). Descriptions of sampling time, frequency, and intensity as well as preparation, archiving, and quality control are given by Robertson et al. Soil microbiological data obtained from soil samples become more informative if supplemented by information on the soil physical, chemical, and biotic factors.

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